International Journal of Applied Biology and Environmental Sciences
E-ISSN: 2667-6540   5(1): 1-17, 2023
Doi: 10.5505/ijabes.2023.80774
Research Article

STATISTICAL EXAMINATION OF YIELD AND QUALITY COMPONENTS IN WHEAT (*T.aestivum* L.)

Zekiye Budak Başçiftçi[1], Murat Olgun[1], Nazife Gözde Ayter Arpacıoğlu[1], Arman Atalar[2], Metin Turan[3]

[1]*Osmangazi University, Faculty of Agriculture, Field Crop Department, Eskişehir*
[2]*Osmangazi University, Sivrihisar Vocational School, Eskişehir*
[3] *Yeditepe University, Department of Agricultural Trade and Management, Istanbul*
**Corresponding Author:*
E-mail: gayter@ogu.edu.tr

(Received 14th March 2023; accepted 06th May 2023)

ABSTRACT. The aim of this study was to determine certain characters, having significant effect in seed yield and protein content by statistical analyze methods, conditional formatting, correlation and path, multiple linear stepwise regression, factor, biplot, decision tree and phyton regression analyzes in bread wheat. This study was carried out under arid conditions in the experimental field of the Faculty of Agriculture of ESOGU during the cultivation period of 2019-2020 and 2020-2021. In the study, seed yield, heading day, plant height, seed number and weight/spike, spike length, SPAD, chlorophyll a and b, thousand seed weight, test weight, protein content, micro sedimentation were examined. The two-year averages of the results of the examined elements were taken into account and statistical analyzes were made on these results. As statistical analyzes; conditional formatting, correlation and path, multiple linear stepwise regression, factor, biplot, decision tree and phyton regression were used. It was determined that seed number/spike, seed weight/spike, micro sedimentation, SPAD, chlorophyll a and chlorophyll b were were found to be effective parameters on seed yield and protein content.

Keywords: *Bread wheat, genotype, yeld and quality components, conditional formatting, correlation and path, multiple linear stepwise regression, factor, biplot, decision tree and phyton regression analyses*

INTRODUCTION

Wheat, which is an important species among cereals, occupies an important place in the world's nutrition and ranks first in the world in terms of cultivation and production [1, 2]. Besides, wheat is very important in meeting the food needs of people, with its high adaptability, harvesting, transportation, storage and conversion into product, especially in terms of the nutrients it contains. In addition, products such as flour, bread, pasta, biscuits obtained from wheat are important in human nutrition; Bran and stems are used as a source of carbohydrates in animal nutrition [3, 4, 5]. In order to provide a balanced diet for the growing population in the world, it is necessary to increase the production. For this purpose, it is necessary to use proprietary varieties with high yield, quality, and resistant to biotic and abiotic stresses. In addition, agronomic requirements such as appropriate planting methods, fertilization, irrigation, and weed control are required for high yields [6, 7, 8]. In bread wheat breeding programs; developing high yielding, disease and pest resistant, stabile and adapted, cold and drought resistant, good quality genotypes are needed. With the breeding programs carried out in recent years, high yielding and quality, disease and pest resistant genotypes have been developed and given to use of farmers/producers [8, 9, 10]. It has been stated that chlorophyll measurements at certain periods during plant development contribute to high yield [11, 12, 13]. Again, considering yield components such as the spike number/m², plant height, seed number and weight/spike and using them in breeding programs will provide significant advantages in development high-yielding genotypes [10, 14, 15]. Genotypes keeping plant height almost same should be selected for high-yielding genotype development for dry conditions [16]. In addition, the effective use of quality components such as test weight, protein content, thousand seed weight and gluten content in breeding programs is very important in the development of high quality genotypes [17, 18].

In the last thirty years, the bread wheat breeding vision has shifted to the development of high yielding and quality genotypes, and protein content, sedimentation, thousand-seed weight and test weight have been revealed as the most important components for high yield and quality [19, 20]. Meanwhile, in recent years, many statistical methods have been used to determine the components affecting yield and quality [21, 22]. For this purpose, statistical methods such as correlation and path, stepwise regression, factor and biplot analysis have been used as effective methods to determine the effective componentss [21, 22, 23]. In this study, the effective components affecting seed yield and protein content were aimed to determine by conditional formatting, correlation and path, multiple linear stepwise regression, factor, biplot, decision tree and phyton regression analyses in bread wheat.

MATERIALS AND METHODS

This study was carried out in the experimental area of the Faculty of Agriculture, ESOGU during the cultivation period of 2019-2020 and 2020-2021 under arid conditions. Some climatic data of the vegetation period of 2019-2020 and 2020-2021 were given in Table 1.

Table 1. Some climatic data in vegetation period of 2019-2020 and 2020-2021.

Months	2019/2020		2020/2021		Long Term Mean (1970-2021)	
	Precipitation (mm)	Mean Temp. (°C)	Precipitation (mm)	Mean Temp. (°C)	Precipitation (mm)	Mean Temp. (°C)
October	20,8	15	39,5	17	18	13,2
November	18,9	10,3	28,2	12,4	27,5	7,3
December	32,8	3,9	43,6	6	31,5	2,5
January	39	-3,6	50,4	-0,4	40,5	0,2
February	28,2	-2,3	41,5	0,9	35,3	1,7
March	34,7	1,6	34,4	3,7	39,3	5,7
April	36,8	8,2	19,4	10,3	42,2	11,2
May	22,7	12,9	19,8	15	51,3	16,1
June	35,8	16,8	7,5	16,8	35,2	20
Tot/Mean	269,7	7,0	284,3	9,1	320,8	8,7

As seen in Table 1, the total precipitations for the nine months in 2019-2020 and 2020-2021 were 269,7 mm and 284,3 mm, less than the total precipitation for long-term years (320,8 mm). Again, the nine-month average temperature was 7,0°C in 2019-2020 and 9,1°C in 2020-2021. The average temperature for long-term years was 8.7°C. The soil in the study area had a clay-loamy texture and the lime level was moderately high and slightly alkaline. Soil was poor in organic matter. Bread wheat genotypes, Müfitbey, Atay-85, Çetinel-2000, Bayraktar-2000, Alpu-01, Bezostaja-1, Rumeli, Tosunbey, ES-26, Reis, Palandöken-97, Ayyıldız, Altay-2000, Yıldırım, Eser, Demir-2000, Gerek-79, Yunus, Sultan-95, Sönmez-2001, Atay-85, Zencirci, İkizce and Harmankaya-99, were used in the study. The study was set up in a randomized block design with 3 replications. The sowing was made between 1-15 October with a seed drill at 20 cm row spacing (6 m x 1.20 m = 7.6 m^2, 650 seeds/m^2). 0,06 t/ha P2O5 and 0,06 t N/ha fertilizer were applied to bread wheat varieties. All of the phosphorus was given with the planting. Half of the nitrogen was applied by dividing it into two, with the other half during the sowing period. As weed control, 1600 cc/ha weed control was made with 2,4-D amine weed pesticide against broad-leaved weeds during the early stemming period.

In the experiment, seed yield (t/ha) [24], heading date (days) [25], plant height (cm) [26], seed number and weight(g) [27, 28], of spike number/m² [29], spike length (cm) [30], SPAD [31], chlorophyll a and b [32], thousand seed weight (g) [33], test weight (kg/hl) [34], protein content (%) [35, 36], micro sedimentation (ml) [37] ,was examined. The averages of two years in components examined were taken into account and statistical analyses were made on these results. As statistical analyse methods; conditional formatting, correlation and path, multiple linear stepwise regression, factor, biplot, decision tree and phyton regression analysis methods were used.

RESULTS AND DISCUSSION

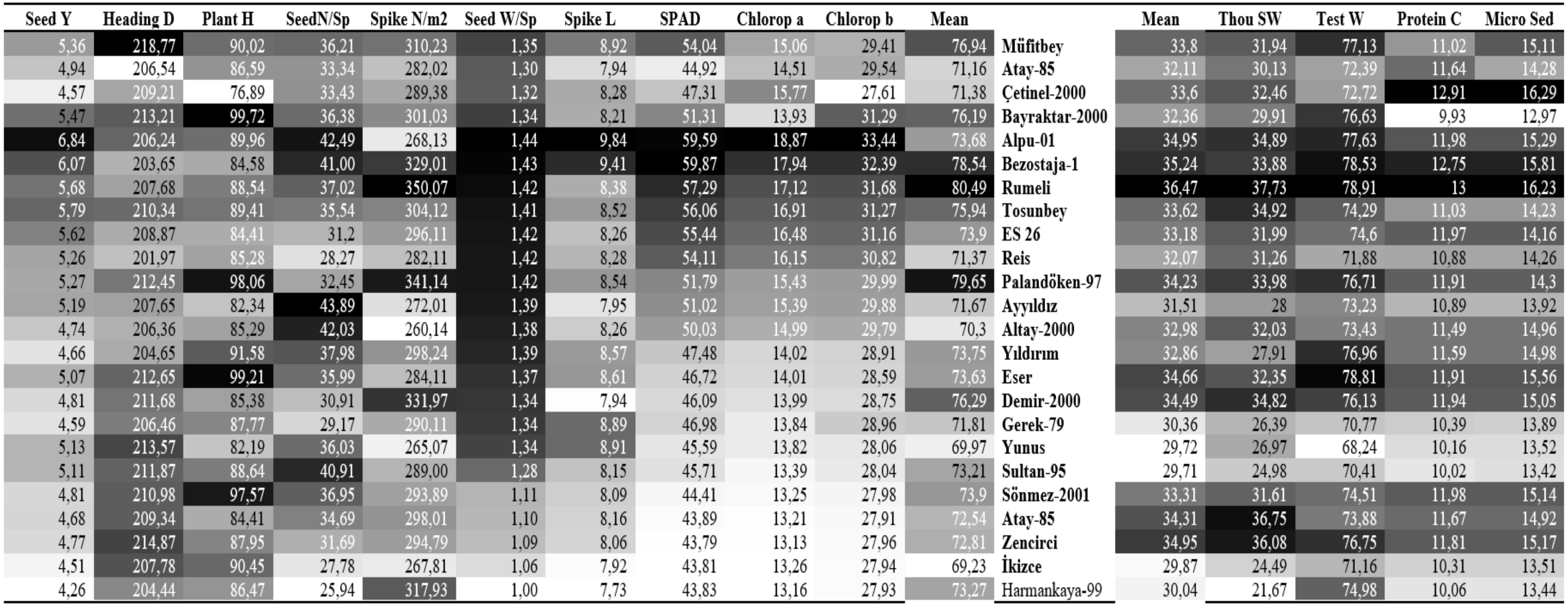
Second Level Heading (Heading 2) With Sentence Case (Italic)

Inadequate and unbalanced nutrition is one of the most important issues all countries of the world today. For this purpose, the aim of wheat breeding activities in the world; is to develop wheat genotypes, high yielding, high quality, adapted to different environments and years, stabile, resistant to winter, drought, diseases, lodging and meet the demands of consumers, industrialists and producers. [29, 31,34, 35, 36]. In the breeding studies carried out in recent years, main purpose was to apply fast and effective components in selecting and developing promising novel genotypes [27, 28, 25, 36]. For this purpose, different yield and quality components were analysed according to many statistical methods, and the effects of common elements revealed by these methods on yield/quality.

Conditional Formatting Analysis

In recent years, the conditional formatting analysis method has found its place in breeding and has started to be used. In this method, the components discussed were presented in different indicator chart values from the smallest to the largest, and the averages of these components could be evaluated practically and effectively [38, 39]. The yield and quality components examined in our study were evaluated according to the conditional formatting method, and the results were given in Table 2. As seen in Table 2, yield and quality components were evaluated one by one and analysed together. Alpu-01 genotype in seed yield, spike length, chlorophyll a, chlorophyll b and seed weight/spike, Müfitbey genotype in heading date, Bayraktar 2000 genotype in plant height, Ayyıldız genotype in the seed number of/spike, Palandöken-97 genotype in spike number/m², Bejostaja-1 genotype in SPAD gave the highest values. As a means of yield components, Bezostaja-1, Rumeli and Palandöken-97 were determined as the best genotypes (Table 2). Considering the quality components, Rumeli genotype gave highest values in thousand seed weight and protein content.

Table 2. Evaluation of the yield and qualiy components examined by the conditional formatting method.



Seed Y	Heading D	Plant H	SeedN/Sp	Spike N/m2	Seed W/Sp	Spike L	SPAD	Chlorop a	Chlorop b	Mean		Mean	Thou SW	Test W	Protein C	Micro Sed
5,36	218,77	90,02	36,21	310,23	1,35	8,92	54,04	15,06	29,41	76,94	**Müfitbey**	33,8	31,94	77,13	11,02	15,11
4,94	206,54	86,59	33,34	282,02	1,30	7,94	44,92	14,51	29,54	71,16	**Atay-85**	32,11	30,13	72,39	11,64	14,28
4,57	209,21	76,89	33,43	289,38	1,32	8,28	47,31	15,77	27,61	71,38	**Çetinel-2000**	33,6	32,46	72,72	12,91	16,29
5,47	213,21	99,72	36,38	301,03	1,34	8,21	51,31	13,93	31,29	76,19	**Bayraktar-2000**	32,36	29,91	76,63	9,93	12,97
6,84	206,24	89,96	42,49	268,13	1,44	9,84	59,59	18,87	33,44	73,68	**Alpu-01**	34,95	34,89	77,63	11,98	15,29
6,07	203,65	84,58	41,00	329,01	1,43	9,41	59,87	17,94	32,39	78,54	**Bezostaja-1**	35,24	33,88	78,53	12,75	15,81
5,68	207,68	88,54	37,02	350,07	1,42	8,38	57,29	17,12	31,68	80,49	**Rumeli**	36,47	37,73	78,91	13	16,23
5,79	210,34	89,41	35,54	304,12	1,41	8,52	56,06	16,91	31,27	75,94	**Tosunbey**	33,62	34,92	74,29	11,03	14,23
5,62	208,87	84,41	31,2	296,11	1,42	8,26	55,44	16,48	31,16	73,9	**ES 26**	33,18	31,99	74,6	11,97	14,16
5,26	201,97	85,28	28,27	282,11	1,42	8,28	54,11	16,15	30,82	71,37	**Reis**	32,07	31,26	71,88	10,88	14,26
5,27	212,45	98,06	32,45	341,14	1,42	8,54	51,79	15,43	29,99	79,65	**Palandöken-97**	34,23	33,98	76,71	11,91	14,3
5,19	207,65	82,34	43,89	272,01	1,39	7,95	51,02	15,39	29,88	71,67	**Ayyıldız**	31,51	28	73,23	10,89	13,92
4,74	206,36	85,29	42,03	260,14	1,38	8,26	50,03	14,99	29,79	70,3	**Altay-2000**	32,98	32,03	73,43	11,49	14,96
4,66	204,65	91,58	37,98	298,24	1,39	8,57	47,48	14,02	28,91	73,75	**Yıldırım**	32,86	27,91	76,96	11,59	14,98
5,07	212,65	99,21	35,99	284,11	1,37	8,61	46,72	14,01	28,59	73,63	**Eser**	34,66	32,35	78,81	11,91	15,56
4,81	211,68	85,38	30,91	331,97	1,34	7,94	46,09	13,99	28,75	76,29	**Demir-2000**	34,49	34,82	76,13	11,94	15,05
4,59	206,46	87,77	29,17	290,11	1,34	8,89	46,98	13,84	28,96	71,81	**Gerek-79**	30,36	26,39	70,77	10,39	13,89
5,13	213,57	82,19	36,03	265,07	1,34	8,91	45,59	13,82	28,06	69,97	**Yunus**	29,72	26,97	68,24	10,16	13,52
5,11	211,87	88,64	40,91	289,00	1,28	8,15	45,71	13,39	28,04	73,21	**Sultan-95**	29,71	24,98	70,41	10,02	13,42
4,81	210,98	97,57	36,95	293,89	1,11	8,09	44,41	13,25	27,98	73,9	**Sönmez-2001**	33,31	31,61	74,51	11,98	15,14
4,68	209,34	84,41	34,69	298,01	1,10	8,16	43,89	13,21	27,91	72,54	**Atay-85**	34,31	36,75	73,88	11,67	14,92
4,77	214,87	87,95	31,69	294,79	1,09	8,06	43,79	13,13	27,96	72,81	**Zencirci**	34,95	36,08	76,75	11,81	15,17
4,51	207,78	90,45	27,78	267,81	1,06	7,92	43,81	13,26	27,94	69,23	**İkizce**	29,87	24,49	71,16	10,31	13,51
4,26	204,44	86,47	25,94	317,93	1,00	7,73	43,83	13,16	27,93	73,27	Harmankaya-99	30,04	21,67	74,98	10,06	13,44

Çetinel-2000 genotype had the highest value in micro sedimentation. Rumeli, Palandöken-97, Eser, Demir-2000 and Zencirci genotypes were the best ones in quality components (Table 2). As a result, when the yield and quality componentss are considered together, Bezostaja-1, Rumeli and Palandöken-97 genotypes gave higher performance in yield and quality varieties.

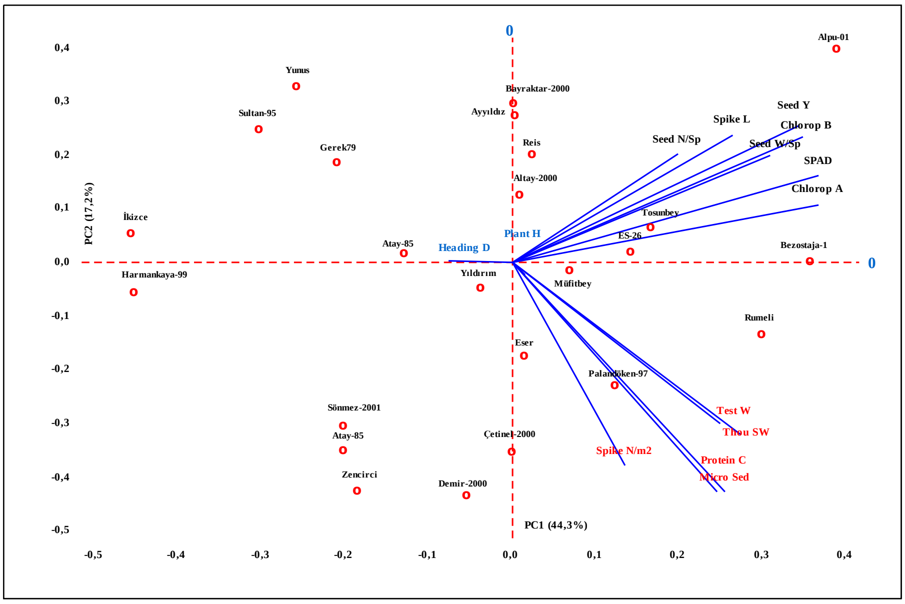
Principal Component Analysis

Principal component analysis is so useful method in terms of defining, classifying and evaluating the examined components. In other words, considering the correlation ratios between the components, the variations among them are evaluated and fewer important variables are determined [40, 41]. The evaluations made according to the principal component and biplot analyses in our study were given in Table 3. As seen from Table 3, the variances of the other components were evaluated based on seed yield and protein.

Plant height, seed number and weight, SPAD, chlorophyll a and b were revealed as interacting analyses with yield. Micro sedimentation, thousand seed weight and test weight were also important quality components interacting with protein content. If the biplot analysis is examined, the components affecting the yield formed one group, while the other components affecting the quality formed another group. The heading date constituted the separate group. Along with seed yield, seed number and weight, SPAD, chlorophyll a and b, spike length were important components affecting yield. Similarly, thousand seed weight, test weight, micro sedimentation and spike number/m² were revealed as components affecting the quality. Considering all the examined components, Bezostaja-1, Alpu-01, Rumeli, Palandöken-97, Tosunbey, Es-26, Müfitbey cultivars were expressed as high yield and quality genotypes.

Table 3. Evaluations on yield and quality components according to principal component and biplot analysis.

	PC_1	PC_2	PC_3	**Variable**	PC_1	PC_2	PC_3
Eigenvalue	6,1980	2,4096	1,8121	**Seed W/Sp**	**0,310**	0,197	-0,105
Proportion	0,443	0,172	0,129	**Spike L**	0,265	0,237	0,115
Cumulative	0,443	0,615	0,744	**Thou SW**	0,073	-0,123	**0,420**
Variable	PC_1	PC_2	PC_3	**Test W**	0,109	**-0,301**	0,110
Seed Y	**0,343**	0,253	0,150	**Protein C**	0,246	**-0,430**	-0,231
Heading D	-0,076	0,003	**0,533**	**Micro Sed**	0,155	**-0,429**	-0,149
Plant H	0,016	-0,023	0,630	**SPAD**	**0,367**	0,161	0,009
Seed N/Sp	0,199	0,201	0,014	**Chlorop A**	**0,367**	0,107	-0,175
Spike N/m²	0,135	-0,380	0,205	**Chlorop B**	**0,348**	0,103	0,040



Factor Analysis

In this study, factor analysis is another form of analysis. Although factor analysis is similar to principle component analysis, it shows relative differences in practice. In this analysis, the number of variables is reduced by gathering the related components under a group, and the characteristics of the components examined with these few components are analysed. By rotating the obtained results, more efficient and less number of factors is obtained, and thus clearer results are revealed. In other words, the correlation importance and priorities of the examined components are gathered together and explained as factors [42, 43]. The factor analysis performed in our study was given in Table 4.

Table 4. Factor analysis, made in yield and quality components.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0,629
Bartlett's Test of Sphericity	**Approx. Chi-Square**	381,430
	df	91
	Sig.	0,000

Total Variance Explained

	Initial Eigenvalues			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
Component	**Total**	**Variance %**	**Cumulative %**	**Total**	**Variance %**	**Cumulative %**	**Total**	**Variance %**	**Cumulative %**
1	6,193	44,234	44,234	6,193	44,234	44,234	5,078	36,274	36,274
2	2,413	17,237	61,472	2,413	17,237	61,472	3,329	23,781	60,054
3	1,812	12,942	74,414	1,812	12,942	74,414	1,778	12,702	72,756
4	1,116	7,973	82,387	1,116	7,973	82,387	1,348	9,631	82,387

Rotated Component Matrix

	Factor$_1$	**Factor$_2$**	**Factor$_3$**	**Factor$_4$**		**Factor$_1$**	**Factor$_2$**	**Factor$_3$**	**Factor$_4$**
Seed Y	**0,933**	0,122	0,184	-0,083	**Thou SW**	0,290	**0,813**	0,103	0,034
Heading D	-0,201	-0,041	**0,79**6	-0,267	**Test W**	0,339	0,602	0,464	0,376
Plant H	0,086	-0,090	**0,801**	0,278	**Protein C**	0,132	**0,942**	-0,220	0,041
SeedNS/p	0,469	0,202	0,137	-0,610	**Micro Sed**	0,147	**0,964**	-0,098	-0,003
SpikeNM2	0,101	0,443	0,189	**0,725**	**SPAD**	**0,932**	0,231	-,030	0,084
SeedW/Sp	**0,812**	0,157	-0,162	-0,064	**Chlorop A**	**0,862**	0,351	-0,250	-0,003
Spike L	0,698	0,138	0,203	-0,349	**Chlorop B**	**0,966**	0,084	-0,016	0,132

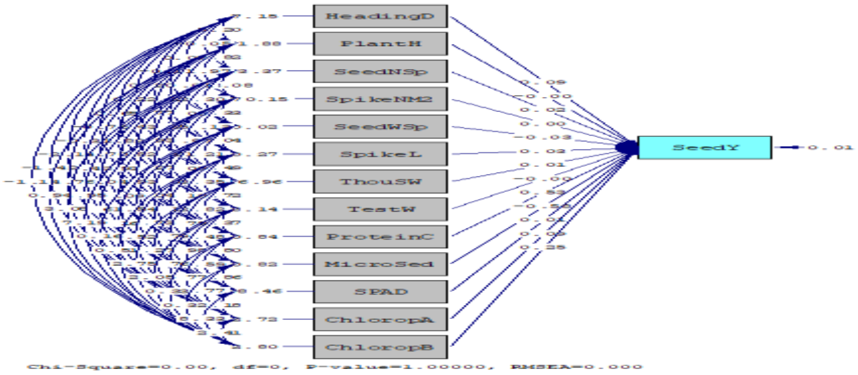
In the analysis, the Kaiser-Meyer-Olkin proficiency measure was found to be above 0.5, and the Barlett test was determined as very important. The analyses were concluded in 3 stages, and as a result of the analysis, the important components affecting the seed yield were determined as chlorophyll a and b, SPAD, seed number and weight/spike. Again, the components affecting the protein were determined as micro sedimentation, thousand seed weight and plant height.

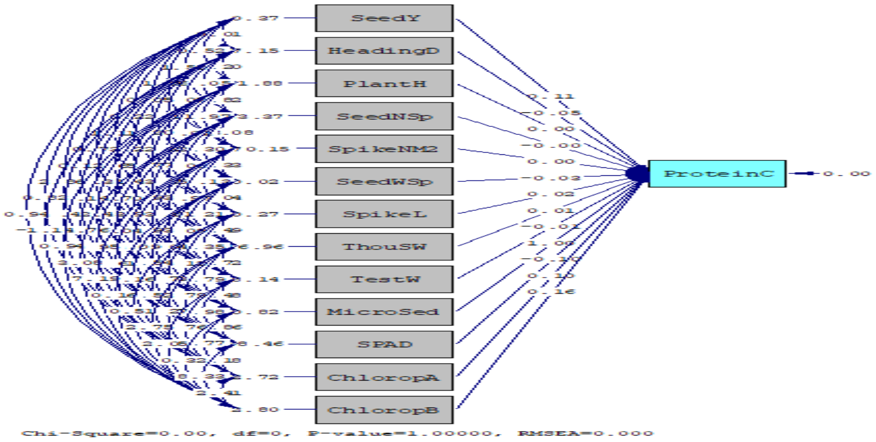
Correlation and Path Analyses

Correlation, varying between +1 and -1 values, shows the strength of the relationship between two or more component. Positive values indicate a positive relationship between components, and negative relationships indicate a negative relationship between components. Correlation analysis shows the strength of the relationship between components, examined in many scientific studies, including agricultural studies [43, 44, 45]. Path analysis is also an analysis based on the grading of significance depending on the correlation coefficient power of the independent components on the dependent variable [45, 46]. In this analysis, the effect of the correlation coefficients is taken into consideration and the effect of the independent components on the dependent variable is determined by ordering them from the most important to the least important. The correlation coefficients between the components examined in our study and the path analysis showing the effect of other components on seed yield and protein content, considered as dependent components, were given in Table 5.

Table 5. The correlation coefficients and path analysis between components with the seed yield and protein content(dependent variables).

	Seed Y	**Heading D**	**Plant H**	**Seed N/Sp**	**Spike N/m^2**
Heading D	0,008ns				
Plant H	0,152ns	0,345ns			
Seed N/Sp	0,521**	-0,004ns	0,030ns		
Spike N/m^2	0,113ns	0,001ns	0,185ns	-0,200ns	
Seed W/Sp	0,667**	-0,308ns	-0,019ns	0,465ns	0,103ns
Spike L	0,687**	0,141ns	0,076ns	0,421*	-0,010ns
Thou SW	0,445*	0,019ns	0,033ns	0,219ns	0,376ns
Test W	0,422ns	0,085ns	0,461*	0,212ns	0,596**
Protein C	0,189ns	-0,310ns	-0,159ns	0,185ns	0,376ns
Micro Sed	0,215ns	-0,127ns	-0,137ns	0,214ns	0,415*
SPAD	0,885**	-0,150ns	-0,014ns	0,389ns	0,268ns
Chlorop A	0,817**	-0,322ns	-0,188ns	0,370ns	0,169ns
Chlorop B	0,931**	-0,254ns	0,100ns	0,381ns	0,180ns
	Seed W/Sp	**Spike L**	**Thou SW**	**Test W**	**Protein C**
Spike L	0,564**				
Thou SW	0,376ns	0,230ns			
Test W	0,255ns	0,232ns	0,572**		
Protein C	0,285ns	0,202ns	0,745**	0,522**	
Micro Sed	0,292ns	0,256ns	0,751**	0,576**	0,968**
SPAD	0,754**	0,622**	0,446*	0,459*	0,325ns
Chlorop A	0,714**	0,608**	0,483*	0,376ns	0,507*
	0,727**	0,592**	0,399*	0,429*	0,217ns
	Micro Sed	**SPAD**	**Chlorop A**		
SPAD	0,385ns				
Chlorop A	0,514*	0,930**			
	0,208ns	0,933**	0,873**		





As seen in the table, seed yield and seed number and weight/spike, spike length, thousand seed weight, SPAD, chlorophyll a and b were found to be positively and significantly related components. The protein content and thousand seed weight, test weight, micro sedimentation, SPAD were positively and significantly correlated. In Path analysis, the seed number and weight/spike, chlorophyll a and b, SPAD were found as effective components in seed yield. Micro sedimentation, thousand seed weight, test weight and seed yield were the components affecting protein content. Again, Bezostaja-1, Palandöken-97, Tosunbey, ES-26, Rumeli, Müfitbey varieties were determined as high performance and stable genotypes for yield and quality components.

Multiple Linear Stepwise Regression Analysis

Multiple linear stepwise regression analysis, a sub-analysis of regression analysis, is a safe method widely used in scientific studies. The components discussed in this analysis are categorized and grouped as dependent and independent components. Therefore, this analysis reveals the important form of the relationship between the dependent variable and the independent components [47, 48]. In the multiple linear stepwise regression analysis, the effects of the independent components on the dependent component are handled according to the degree of importance [49]. Seed yield and protein content were analysed separately in the multiple linear stepwise regression analysis performed in our study. In the multiple linear stepwise regression analysis examined in the three-step model, the effect of the other examined independent regressions on the seed yield, which was considered as the dependent component, was found to be significant at the level of 1% (R2: 94.7%). Again, chlorophyll b, heading date and seed number/spike seed yield components had significant effect on seed yield. Again, the effect of the independent components on the protein content was concluded in five model steps and these effects were significant at the 1% level. (R2: 99.4%). Micro sedimentation, heading date, SPAD, chlorophyll a and b had a significant effect on protein content.

Table 6. Multiple linear stepwise regression analysis showing the effect of independent variables on seed yield and protein content (dependent variables).

Seed Yield — **Model Summary**

Model	**R**	**R^2**	**Adjusted R^2**	**Estimate S_x**
1	0,931	0,867	0,861	0,225
2	0,965	0,931	0,924	0,167
3	0,977	0,954	0,947	0,139

Protein Content — **Model Summary**

Model	**R**	**R^2**	**Adjusted R^2**	**Estimate S_x**
1	0,968	0,936	0,933	0,237
2	0,986	0,971	0,969	0,162
5	0,998	0,996	0,994	0,070

Seed Yield^a — **ANOVA**

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	7,310	1	7,310	143,713	0,000^b
	Residual	1,119	22	,051		
	Total	8,429	23			
2	**Regression**	7,845	2	3,922	140,851	0,000^c
	Residual	0,585	21	0,028		
	Total	8,429	23			
3	**Regression**	8,042	3	2,681	138,236	0,000^d
	Residual	0,388	20	0,019		
	Total	8,429	23			

a. **Dependent Variable:** SeedY **b. Predictors:** (Constant), Chlorop B **c. Predictors:** (Constant), Chlorop B, Heading D d**. Predictors:** (Constant), Chlorop B, Heading D, Seed N/Sp

Protein Content^a — **ANOVA**

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	**Regression**	18,166	1	18,166	322,520	0,000^b
	Residual	1,239	22	0,056		
	Total	19,406	23			
2	**Regression**	18,851	2	9,426	356,988	0,000^c
	Residual	0,554	21	0,026		
	Total	19,406	23			
5	**Regression**	19,319	5	3,864	800,668	0,000^f
	Residual	0,087	18	0,005		
	Total	19,406	23			

a. Dependent Variable: ProteinC **b. Predictors:** (Constant), MicroSed **c. Predictors:** (Constant), Micro Sed, Heading D **f. Predictors:** (Constant), Micro Sed, Heading D, SPAD, Chlorop B, Chlorop A

Seed Yield — **Coefficients**

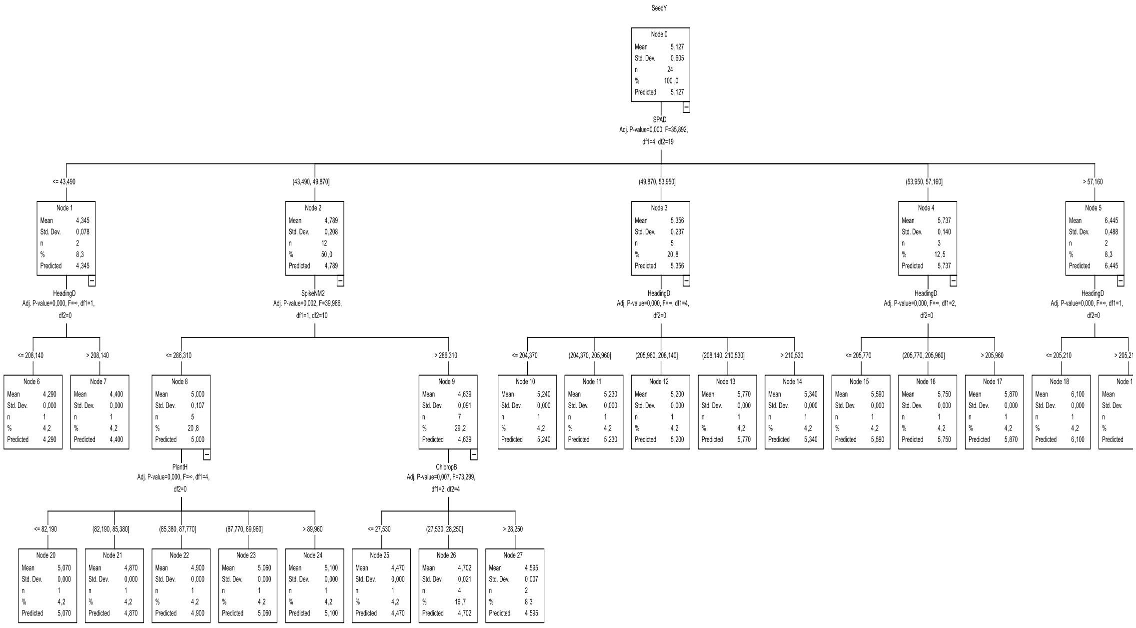
Model		Unstandardized Coefficients B	S_x	Standardized Coefficients Beta	t	Sig.
1	**(Constant)**	-4,745	0,825		-5,753	0,000
	Chlorop B	0,337	0,028	0,931	11,988	0,000
2	**(Constant)**	-17,687	3,017		-5,862	0,000
	Chlorop B	0,361	0,022	0,997	16,784	0,000
	HeadingD	0,059	0,013	0,260	4,380	0,000
3	**(Constant)**	-16,913	2,529		-6,687	0,000
	Chlorop B	0,337	0,020	0,930	17,239	0,000
	Heading D	0,055	0,011	0,244	4,888	0,000
	Seed N/Sp	0,021	0,007	0,166	3,187	0,005

Protein Content **Coefficients**

Model		Unstandardized Coefficients B	S_x	Standardized Coefficients Beta	t	Sig.
	(Constant)	-3,049	0,795		-3,836	0,001
	Micro Sed	0,984	,055	0,968	17,959	0,000
2	**(Constant)**	10,815	2,776		3,895	0,001
	Micro Sed	0,960	00,038	0,944	25,376	0,000
	Heading D	-0,065	0,013	-0,189	-5,092	0,000
5	**(Constant)**	1,502	1,679		0,894	0,383
	Micro Sed	1,044	0,023	1,027	45,154	0,000
	Heading D	0-,039	0,007	-0,115	-5,822	0,000
	SPAD	-0,109	0,012	-0,632	-9,093	0,000
	Chlorop B	0,233	0,030	0,425	7,814	0,000
	Chlorop A	0,088	0,032	0,158	2,765	0,013

Desicion Tree Analysis

The decision tree graphs dealing with seed yield and quality components were shown in Figures 1 and 2. In the decision tree graph (Figure 1), where the seed yield is discussed, the main shaping factor for the seed yield was determined as SPAD.



SPAD ***Main Determinant***

If **SPAD**≤43,490 **SY** is 4,345 **Heading D** *Main Determinant*

If **Heading D**≤ **SY** is 4,290 If **Heading D**> **SY** is 4,400

If **SPAD** 43,490-49,870 **SY** is 4,789 **Spike N/m²** *Main Determinant*

If **Spike N/m²**≤ 286,310 **SY** is 5,000 Plant H *Main Determinant*

If **Plant H**≤ 82,190 **SY** is 5,070, If **Plant H** 82,190-85,380 **SY** is 4,870, If **Plant H** 85,380--87,770 **SY** is 4,900

If **Plant H** 87,770-89,960 **SY** is 5,060, If **Plant H**> 89,960 **SY** is 5,100

If **Spike N/m²**> 286,310 **SY** is 4,689 **Chlorop B** *Main Determinant*

If **Chlorop B**≤ 27,530 **SY** is 4,470, If **Chlorop B** 27,530-28,250 **SY** is 4,702, If **Chlorop B**> 28,250 **SY** is 4,595

If **SPAD** 49,870-53,950 **SY** is 5,356 **Heading D** *Main Determinant*

If **Heading D**≤ 207,370 **SY** is 5,240 If **Heading D** 204,370-205,960 **SY** is 5,230

If Heading D 20,960-208,140 SY is 5,200 If **Heading D** 208,140-210,530 **SY** is 5,5770

If **Heading D**> 210,530 **SY** is 5,340

If **SPAD 5**3,950-57,160 **SY** is 5,737 **Heading D** *Main Determinant*

If **Heading D** ≤ 205,770 **SY** is 5,590 If **Heading D** 205,770-205,960 **SY** is 5,750

If **Heading D** ≤ 205,960 **SY** is 5,870

If **SPAD** > 57,160 **SY** is 6,445 **Heading D** *Main Determinant*

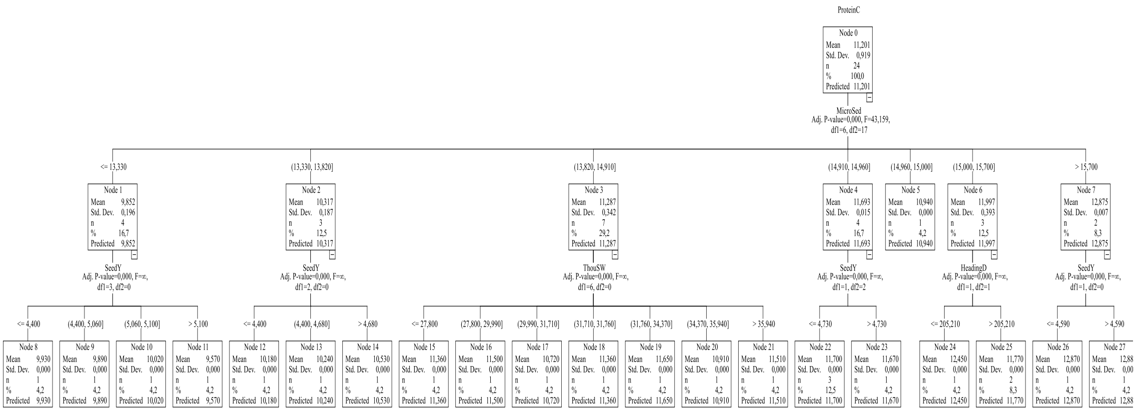
If **Heading D**≤ 205,310 **SY** is 6,100 If **Heading D**> 205,310 **SY** is 6,790

Figure 1. Decision tree graph of the components affecting seed yield.

Under the SPAD, heading date and spike number/m2 were determined as secondary important components. After that, plant height and chlorophyll b emerged as important components. In the decision tree graph, the seed yield varied about 4.2 t/ha and 5.9 t/ha. This means that the seed yield significantly increased when optimum yield component values were obtained. In the studies carried out, spike number/m2, chlorophyll related components (SPAD, chlorophyll a and b), heading date and plant height were found as important yield components, and they have both direct and indirect effects on the seed yield [50, 51]. It has also been mentioned that spike number/m2 and chlorophyll b had important effect in seed yield [52].

When the quality of wheat is considered, the first components that come to mind are protein content and sedimentation amount. The high levels of these components, together with the high yield, make wheat varieties stand out as preferred varieties. Today, in breeding studies, varieties with high protein content and sedimentation as well as high yield are preferred and traded [53, 54]. Wheat varieties with protein higher than 12% in wheat gain importance as bread wheat, but those with less than 11% are preferred as biscuit wheat [55, 56]. In recent years, as a result of the development of the biscuit industry and the increase in the demand for biscuits in the societies, the consumption of biscuits has increased rapidly. As a result, the trade of low protein and sedimentation genotypes has also increased rapidly [57, 58]. The decision tree graph of the components affecting the protein content was given in Figure 2.

In our study, the most influential component on the protein content was naturally determined as micro sedimentation. According to many studies, high sedimentation amount indicates high protein and low protein content leads to a feature to be evaluated in the biscuit industry with low protein content [53, 54]. In our study, although micro-sedimentation, which emerged as the main determinant, was low, the main determinant was seed yield and thousand-seed weight, but with the increase of micro-sedimentation, seed yield and the number of days to spike were more effective. From this, it becomes clear that micro-sedimentation is closely related to yield and is also shaped by the thousand-seed weight and the number of days to spike. Micro sedimentation showed a variation of about 9.8 to 12.9 ml. As a result, micro-sedimentation increased with the increase in seed yield and thousand seed weight, and thus, an increase in protein occurred. As a result of both tree plots, seed yield and protein content are affected by environmental conditions, but they can also vary depending on plant performance, that is, genetic capacity. The increase in this genetic capacity increases depending on the high photosynthetic capacity and the increase in agronomic characteristics, and this situation affects the quality and yield considerably.



Micro Sed ***Main Determinant***

If **Micro Sed**≤13,330 **Protein C** is 9,852 **Seed Y** *Main Determinant*

If **Seed Y**≤ 4,400 **Protein C** is 9,930, If **Seed Y**4,400-5,160 **Protein C** is 9,890, If **Seed Y 5**,060-5,1100 Protein C is 10,020,

If Seed Y> 5,100 Protein C is 9,570

If **Micro Sed** 13,820-14,910 **Protein C** is 11,287 **Thou SW** *Main Determinant*

If **Thou SW≤ 27**,800 **Protein C** is 11,360, If **Thou SW** 27,800-29,990 **Protein C** is 11,500, If **Thou SW** 29,990-31,710 **Protein C** is 10,720, If **Thou SW** 31,710-31,760 **Protein C** is 11,360, If **Thou SW** 31,760-34,370 **Protein C** is 11,650,

If **Thou SW** 34,370-35,940 **Protein C** is 10,910, If **Thou SW**> 35,940 **Protein C** is 11,510

If **Micro Sed**13,330-13,820 **Protein C** is 10,317 **Seed Y** *Main Determinant*

If **Seed Y**≤ 4,400 **Protein C** is 10,180, If **Seed Y**4,400-4,680 **Protein C** is 10,240, If Seed Y> 4,680 Protein C is 10,530

If **Micro Sed**13,330-13,820 **Protein C** is 10,317 **Seed Y** *Main Determinant*

If **Seed Y**≤ 4,400 **Protein C** is 10,180, If **Seed Y**4,400-4,680 **Protein C** is 10,240, If Seed Y> 4,680 Protein C is 10,530

If **Micro Sed** 14,910-14,960 **Protein C** is 11,693 **Seed Y** *Main Determinant*

If **Seed Y**≤ 4,730 **Protein C** is 11,700, If Seed Y> 4,730 **Protein C** is 11,670

If **Micro Sed** 15,000-15,700 **Protein C** is 10,940

Figure 2. Decision tree graph of the components affecting the protein content.

Phyton Regression Analysis

Phyton regression analysis, which is a statistical method, is used to examine the effects of dependent and independent variables on each other and to express them with a mathematical model [59]. There are different regression models to examine the relationship between variables [60]. A cause-effect relationship is sought between the variables and an interpretation can be made on the relationship. In this mathematical model, if the number of independent variables is one, it is called a simple regression model, and if it is more than one, it is called a multiple regression model. The main purpose here is to create an estimation equation that enables analysis of dependent variables using independent variables [61]. In this study, multiple regression analysis was performed using multiple independent variables, while seed yield was the dependent variable. In this analysis, the equation to be used is as follows: γ the seed yield value as the dependent variable, the independent variables X1,X2 … Xn and β0, β1, β2…. Bn represents the parameters of the independent variables. In addition, $\beta 0$ represents the constant term and ε the error term.

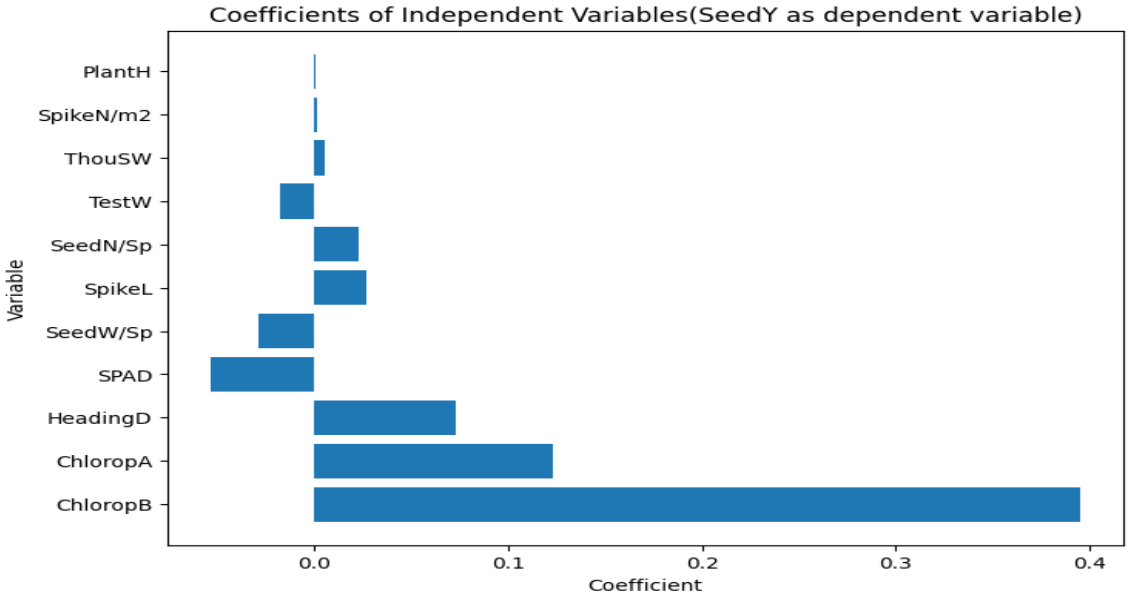
$$\gamma=\beta_0+\beta_1X_1+\beta_2X_2+\cdots+\beta_nX_n+\varepsilon \qquad \text{Formula 1}$$

The Anaconda distribution system was used to construct and use the multiple regression model. To build and analyse the model, the "Jupyter Notebook" interface in Anaconda and python version 3.8.8 were used. The sklearn library was used to create the model, and the matplotlib library was used to visualize the values. At the end of the model training, the coefficients of the variables were obtained and the analysis was performed.

After the multiple regression model, the coefficient values showing the effect of the independent variables on the dependent variable, the seed yield, were given in Table.

***Table** 7*. Coefficient values showing the effect of independent variables on the dependent variable, seed yield.

	Variables	**Coefficient**	**Absolute Coefficient**
X_{11}	**Chlorophyll b**	0,395176	0,395176
X_{10}	**Chlorophyll a**	0,122830	0,122830
X_1	**Heading Date**	0,072892	0,072892
X_9	**SPAD**	-0,053253	0,053253
X_5	**Seed Weight/Spike**	-0,028668	0,028668
X_6	**Spike Length**	0,026521	0,026521
X_3	**Seed Number/Spike**	0,022607	0,022607
X_8	**Test Weight**	-0,017992	0,017992
X_7	**Thousand Seed Weight**	0,005082	0,005082
X_4	**Spike Number/m^2**	0,001500	0,001500
X_2	**Plant Height**	0,000861	0,000861

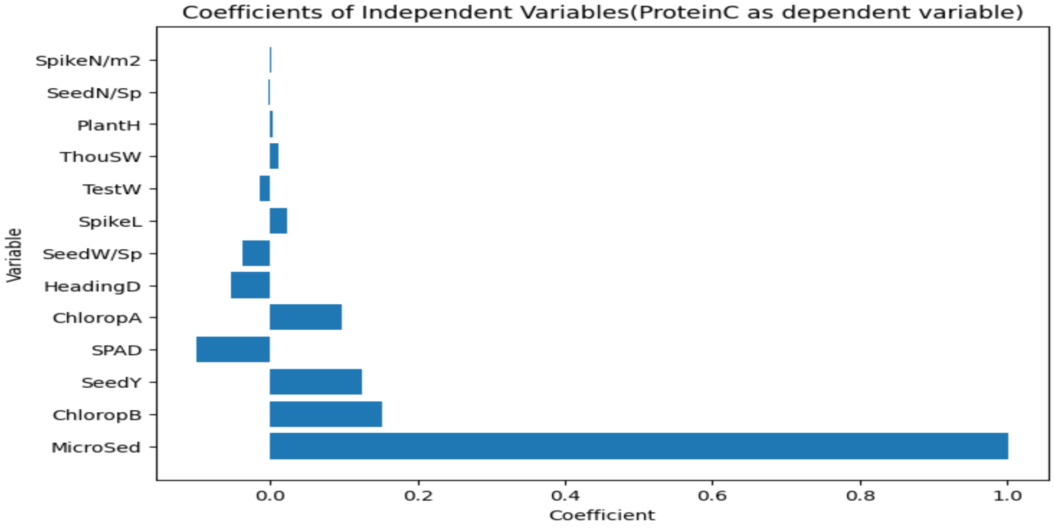


The values of the coefficient of influence of the independent variables on the dependent variable, the seed yield, are given in order from largest to smallest. As a result of the analysis made here, chlorophyll b, chlorophyll a and heading date values, whose values are given exactly, have a positive coefficient. On this seed yield, chlorophyll b has a high positive effect, and chlorophyll a and heading date have a moderate positive effect. After the multiple regression model, the coefficient values showing the effect of the independent variables on the dependent variable, the protein content, were given in Table 8.

Table 8. Coefficient values showing the effect of independent variables on the dependent variable, protein content.

	Variables	**Coefficient**	**Absolute Coefficient**
X_{10}	**Micro Sedimentation**	1,001712	1,001712
X_{13}	**Chlorophyll b**	0,150881	0,150881
X_1	**Seed Yield**	0,123443	0,123443
X_{11}	**SPAD**	-0,099671	0,099671

X_{12}	**Chlorophyll a**	0,097174	0,097174
X_2	**Heading Date**	-0,053594	0,053594
X_6	**Seed Weight/Spike**	-0,037589	0,037589
X_7	**Spike Length**	0,023395	0,023395
X_9	**Test Weight**	-0,014329	0,014329
X_8	**Thou Seed Weight**	0,010993	0,010993
X_3	**Plant Height**	0,004161	0,004161



It has been revealed that the component affecting the protein content, the dependent variable, were micro sedimentation, chlorophyll b and seed yield. As a result of both analyses, chlorophyll a and b, heading date and micro sedimentation components were found as the most effective components on seed yield and quality. As a result of the analyses made, the components affecting seed yield and protein content, and the genotypes determined to be superior performance were given in Table 9.

Table 9. The components affecting seed yield and protein content, and the genotypes determined to be superior performance.

	Conditional Formatting	Principal Component	Biplot	Factor	Correlation	Path	Stepwise Regression	Decision Tree	Pyhton Regreeion
Seed Yield									
Heading Date	☻						☻	☻	☻
Plant Height				☻				☻	
Seed Number/Spike		☻	☻	☻	☻	☻	☻		
Spike Number/m²								☻	
Seed Weight/Spike	☻	☻	☻	☻	☻	☻			
Spike Length			☻		☻				
Thousand Seed Weight	☻	☻	☻	☻	☻				
Test Weight	☻	☻	☻		☻	☻		☻	
Protein Content						☻			
Micro Sedimentation	☻	☻	☻	☻	☻	☻	☻	☻	☻
SPAD	☻	☻	☻	☻	☻	☻	☻	☻	
Chlorophyll A	☻	☻	☻	☻	☻	☻	☻		☻
Chlorophyll B	☻	☻	☻	☻	☻	☻	☻	☻	☻
Genotypes	Bezostaja-1, Rumeli ve Palandöken-97, Alpu-01, Tosunbey, Es-26, Müfitbey								

In the light of Table 9, seed number/spike, seed weight/spike, micro sedimentation, SPAD, chlorophyll a and chlorophyll b were effective components on seed yield and protein content. More detailed studies are needed on this subject. More successful results can be obtained in breeding studies with detailed analyses to be made.

REFERENCES

[1] Meena, B.L., A.K. Singh, B.S. Phogat, H.B. Sharma. (2013): Effects of nutrient management and planting systems on root phenology and seed yield of wheat (Triticum aestivum L.). Indian Journal of Agricultural Sciences, 83 (6), Pp. 627-632.

[2] Anonymous, (2020): Cereal_supply_and_demand_data_may. http://www.fao.org/fileadmin/templates/worldfood.Reports_and_docs/Cereal_supply_and_demand_data_may.xls

[3] Kün, E. (1996): Cereals-I (Cool Season Cereals). Ankara Univ. Agric. Fac., Pub. No:1451, Ankara.

[4] Kumar, P., A. Sarangi, D.K. Singh, S.S. Parihar (2005): Wheat Performance as influenced by Saline Irrigation Regimes and Cultivars, 1 (2), Pp. 66–72.

[5] Chung, O. K., J.-B. Ohm, M. S. Ram, S.-H. Park, and C. A. Howitt (2009): Wheat Lipids. pp. 363–399. in K. Khan, P. R. Shewry, eds. Wheat: chemistry and technology, 4th edn. AACC, St Paul, MN.

[6] Poehlman, J.M., (1987): Breeding Field Crops, Van Nostrand Reinhold Company Inc. 115 Fifth Avenue New York.

[7] Smith, G.P., M.J. Googing (1999): Models of wheat seed quality considering climate, cultivar and nitrogen effects. Agricultural and Forest Meteorology, 94(1):86-93.

[8] Öztürk, A., F. Aydın (2004): Effect of water stress at various growth stages on some quality characteristics of winter wheat. Journal of Agronomy and Crop Science, 190(2), 93-99.

[9] Bağcı, S.A. (1998). Multivariate analysis of computerized Mixograph data for end-use quality improvement in winter wheat. (M.Sc. thesis). South Dakota State University, SD, USA.

[10] Ahmad H.M., S.I. Awan, O. Aziz and M.A. Ali (2014): Multivariative analysis of some metric traits in bread wheat (*Triticum aestivum L.*) Eur J Biotech and Biosci.1 (3):18-21.

[11] Borhan M.S., S. Panigrahi, M.A. Satter (2017): Evaluation of computer imaging technique for predicting the SPAD readings in potato leaves. Inform Process Agric (4):275–82.

[12] Liu C, Y. Liu, Y. Lu (2019): Use of a leaf chlorophyll content index to improve the prediction of above-ground biomass and productivity. PeerJ, 6(1)

[13] Lenaerts, B., B.C.Y. Collard, M. Demont (2019): Improving global food security through accelerated plant breeding. Plant Sci.287, 110207.

[14] Ali Q., A. Ali, M.F. Awan, M. Tariq, S. Ali, T.R. Samiullah, S. Azam, S. Din, M. Ahmad, N.M. Sharif, S. Muhammad, N.H. Khan, M. Ahsan, I.A. Nasir and T. Hussain (2014): Combining ability analysis for various physiological, seed yield and quality traits of Zea mays L. Life Sci J 11(8s):540-551.

[15] Lynch, J.P., D. Doyle, S. McAuley, F. McHardy, Q. Danneels, L. C. Black (2017): The impact of variation in seed number and individual seed weight on winter wheat yield in the high yield potential environment of Ireland. Eur. J. Agron. 87, 40–49.

[16] Ferrante, A., J. Cartelle, R. Savin and G.A. Slafer (2017): Yield determination, interplay between major components and yield stability in a traditional and a contemporary wheat across a wide range of environments. Field Crops Res. 203, 114–127.

[17] Grassini, P., K.M Eskridge and K.G. Cassman (2013): Distinguishing between yield advances and yield plateau in historical crop production trends. Nat. Commun. 4:2918.

[18] Ashfaq S., H.M. Ahmad, S.I. Awan, S.A. Kang, M. Sarfaraz and M.A. Ali (2014): Estimation of genetic variability, heritability and correlation for some morphological traits in spring wheat. J Biol Agric and Healthcare. 4(5).10-16

[19] Mohamed, M.A., J.J. Steiner, S.D. Wright, M.S. Bhangoo and D.E. Millhouse (1990): Intensive crop management practices on wheat yield and quality. Agron. J. 82, 701–707.

[20] Roth, M.G., S. Mourtzinis, J.M. Gaska, B. Mueller, A.D.L. RothSmith (2021): Wheat seed and straw yield, seed quality, and disease benefits associated with increased management intensity. Agron. J. 113, 308–320.

[21] Asseng, S., N.C. Turnera, J.D. Rayb, B.A. Keatingc (2002): A simulation analysis that predicts the influence of physiological traits on the potential yield of wheat. European Journal of Agronomy 17 (2), 123–141.

[22] Slafer, G.A., R. Savin and V.O. Sadras (2014): Coarse and fine regulation of wheat yield components in response to genotype and environment. Field Crops Res. 157, 71–83.

[23] Yin, X., S.D. Chasalow, P.M. Stam, J. Kropff, C.J. Dourleijn, I. Bos, P.S. Bindraban (2002): Use of component analysis in QTL mapping of complex crop traits: a case study on yield in barley. Plant Breeding (August) 121 (4), 314

[24] Yanchev I., T. Kolev and H. Kirchev (2013): Study on Productivity Formation and Yield components of Cereal Crops for Green Mass. Journal of Mountain Agriculture on the Balkans, 16 (6), 1441-1449.

[25] Foulkes M., R. Sylvester-Bradley, R, Weightman, J. Snape (2007): Identifying physiological traits associated with improved drought resistance in winter wheat. Field Crop Res 103:11–24.

[26] Alejandro D.P., M. Iván, D.S. María, L.A. José (2014): Agronomic and physiological traits associated with breeding advances of wheat under high-productive Mediterranean conditions. The Case of Chile, Environ and Exper Bot 103: 180–189

[27] Dokuyucu, T., A. Akkaya (1999): Path coefficient analysis and correlation of seed yield and yield components of wheat genotypes. RACHIS. 18: 17-20.

[28] Dwivedi, A.N., I.S. Pawar, M. Shashi, S. Madan (2002): Studies on variability parameters and character association among yield and quality attributing traits in wheat. Haryana Agric. Univ. J. Res., 32, 2: 77-80.

[29] Bokan, N., M. Malesevic (2004): Influence of Crop Density on Wheat Yield Structure. ActaAgriculturaeSerbica, 9(18), 65-79

[30] Vasilevski G. (1980): Influence of Fertilizers on Development, Yield and Quality of Wheat in Ovce Pole Region. Doctoral thesis. Faculty of Agriculture, Skopje.

[31] Naderi R., H. Ghadiri, N. Karimian (2012): Evaluation of SPAD meter as a tool for N fertilization of rapeseed (Brassica napus L.). Plant Knowledge Journal 1:16-19.

[32] Mahdi, M.A., A.A. Ahmed, E. Derek, K.Y.T. Daniel (2012): A new image processing based technique to determine chlorophyll in plants. American-Eurasian J. Agric. Agric. Sci. (12):1323–1328

[33] Williams P., J.F. El-Haramein, H. Nakkoul and S. Rihawi (1988): Crop Quality Evaluation Methods and Guidelines. Syria: International Center For Agricultural Research in The Dry Areas (ICARDA).

[34] Vasiljevic, S. and O. J. Banasik (1980): Quality Testing Methods for Durum Wheat and Its Products. Department of Cereal Chemistry and Technology, Fargo, North Dakota: North Dakota State University, p.134.

[35] Ünal, Y. (2002): Near Infrared Reflektans Spektroskopinin Hayvan Besleme Bilim Alanında Kullanım İmkanları (Derleme). Lalahan Hay. Arast. Enst. Derg. 45(1): 33-39.

[36] Chandi G.K. and K. Seetharaman (2012): Optimization of gluten peak tester: A statistical approach. Journal of Food Quality, (35):69-75.

[37] Pena R.J. (1990): Sodium Dodecyl Sulfate (SDS) Sedimentation Test, J.Cereal Science, 12:105-112.

[38] Anonymous (2023a): https://www.excel-easy.com/ data- analysis/ conditional-formatting.html

[39] Anonymous (2023b): https://www.scribd.com/document/338172116/Activity-Card-Conditional-Formatting

[40] Sharma S. (1996): Applied multivariate techniques. 1nd ed. John Wiley and Sons, New York. 493 pp.

[41] Westerlund E., R. Andersson, M. Hämäläinen and P. Åman (1991): Principal Component Analysis-an Efficient Tool for Selection of Wheat Samples with Wide Variation in Properties. J. Cereal Sci. 14, 95-104.

[42] Walton, P.D. (1971): The use of factor analysis in determining characters for yield selection in wheat. Euphytica. 20: 416-421

[43] Tadesse, W., E. Bekele (2001): Factor analysis of yield in grasspea (Lathyrus sativus L.). Lathyrus Lathyrism Newsletter. 2: 416-421.

[44] Harman, H.H. (1976): Modern factor analysis. 3nd ed. University of Chicago Press, Chicago. 376 pp

[45] Masood, S.A., S. Ahmad, M. Kashif and Q. Ali (2014): Correlation analysis for seed and its contributing traits in wheat (Triticum aestivum L.). Nat Sci 12(11):168-176.

[46] Doğan, R. (2009): The correlation and path coefficient analysis for yield and some yield components of durum wheat (Triticum turgidum var. durum L.) in west anatolia conditions. Pak J. Bot. 41(3):1081-1089.

[47] Coakley, S.M., R.F. Line (1988): Predicting stripe rust severity on winter wheat using an improved method for analyzing meteorological and rust data. Phytopathology, 78, 543–550.

[48] Nasri, R., A. Kashani, F. Paknejad, S. Vazan, M. Barary (2014): Correlation, path analysis and stepwise regression in yield and yield component in wheat (Triticum aestivum L.) under the temperate climate of Ilam province, Iran. Iran. Indian J. Fundam. Appl. Life Sci., 4(4): 188-198.

[49] El-Orabey, W.M., A.F. Elkot (2020): Prediction of leaf rust severity and yield loss in wheat based on environmental factors. J. Plant Dis. Prot.127, 507–519.

[50] Song Y.Y. and Y. Lu, (2015): Decision tree methods: applications for classification and prediction," Shanghai Arch. Psychiatry, vol. 27, no. 2, p. 130, Apr. 2015.

[51] Rajeswari, S. and K. Suthendran (2019): C5.0: Advanced decision tree (ADT) classification model for agricultural data analysis on cloud, Comput. Electron. Agricult., vol. 156, pp. 530–539, Jan. 2019,

[52] L. Guo, N. Chehata, C. Mallet and S. Boukir (2011): Relevance of airborne lidar and multispectral image data for urban scene classification using Random Forests, ISPRS J. Photogramm. Remote Sens., vol. 66, no. 1, pp. 56–66, Jan. 2011,

[53] Koehler, P. and H. Wieser (2003): Chemistry of cereal seeds. In M. Gobbetti and M. Gänzle, eds. Handbook on sourdough biotechnology. New York: Springer, pp. 11- 45.

[54] Goesaert, H., K. Brijs, W.S. Veraverbeke, C.M. Courtin, K. Gebruers and J.A. Delcour (2005): Wheat flour constituents: how they impact bread quality, and how to impact their functionality. Trends in Food Science & Technology, vol. 16, no. 1-3, pp. 12-30.

[55] Gupta, R.B., I.L. Batey and F. Macritchie (1992): Relationships between protein composition and functional properties of wheat flours. Cereal Chemistry, vol. 69, pp. 125-131.

[56] Bauer, N., P. Koehler, H. Wieser and P. Schieberle (2003): Studies on the effects of microbial transglutaminase on gluten proteins of wheat. I. Biochemical analysis. Cereal Chemistry, vol. 80, no. 6, pp. 781-786.

[57] Wall, J.S. (1979): The role of wheat proteins in determining baking quality. In: D.L. Laidman and R.G. Wyn Jones, eds. Recent advances in the biochemistry of cereals. London: Academy Press, pp. 275-311.

[58] Amjid, M.R., A. Shehzad, S. Hussain, M.A. Shabbir and M.R. Khan (2013): A Comprehensive review on wheat flour dough rheology. Pakistan Journal of Food Sciences, vol. 23, no. 2, pp. 105-123.

[59] Yaran, M.Ö. (2011): The Role of The Banking Sector in Regional Development: An Application on the Relationship between the Banking Sector and the GDP per Capita in the Black Sea Region, Istanbul: Kadir Has University, Institute of Social Sciences.

[60] Arı, A. and H. Önder (2013): Regression Methods Used in Different Data Structures,» Anatolian Journal of Agricultural Sciences, 28(3): 168-174.

[61] Bowerman, B.L., R.T. O'Connell, E. S. Murpree and J.B. Orris (2013): Fundamentals of Business Statistics, Ankara: Nobel Academic Pub.